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DYNAMIC EFFECT OF FACTS ON TRANSIENT STABILITY ANALYSIS OF POWER SYSTEM STABILIZERS BY SOFT COMPUTING TECHNIQUE

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ABSTRACT

This paper presents the effects of Flexible AC Transmission System on transient stability analysis of power system stabilizers. In this proposed technique Static VAR Compensator (SVC) is used to control the transient stability problem. Transient stability is the ability of the power system to maintain synchronism when subjected to severe transient disturbance. The resulting system response involves large excursions of generator rotor angles and is influenced by the nonlinear power-angle relationship. Stability depends on both the initial operating state of the system and the severity of the disturbance. Usually, the system is altered so that the post-disturbance steady state operation differs from that prior to disturbance. Small signal stability is the ability of the power system to maintain synchronism under small disturbances. Such disturbances occur continually on the system because of small variations in loads and generation. The MATLAB based model has been made for power system stabilizers and simulation has been carried out with and without SVC to compare the effectiveness of the proposed compensator.

KEYWORDS: SVC, Power System Stabilizer, Transient Stability, MATLAB

INTRODUCTION

Power system stability is a property of a power system that enables it to remain in a state of operating equilibrium under normal operating conditions and to remain at acceptable state of equilibrium after being subjected to a disturbance. Power system stability is broadly classified into two categories (i) Angle stability (ii) Voltage stability. The rotor angle stability is the ability of interconnected synchronous machines in a power system to remain in synchronism. The angle stability problem involves the study of the electro mechanical oscillations inherent in the power systems. Voltage stability is the ability of a power system to maintain steady acceptable voltages at all the buses under normal operating conditions and after being subjected to a disturbance. The main factor causing voltage instability is the inability of the power system to meet the demand for reactive power. The angle stability problem is divided into two categories.

- Transient stability
- Small signal stability

The disturbance area considered sufficiently small for linearization of system equations to be permissible for purpose of analysis. Instability that may result can be of two forms:

- Steady increase in rotor angle due to lack of sufficient synchronizing torque.
- Rotor oscillations of increasing amplitude due to lack of sufficient damping torque.

The nature of the response to small disturbances depends on a number of factors including the initial operating condition, the transmission system strength and the type of excitation controls used. In practical power system, Small signal stability is largely a problem of insufficient damping of oscillations. Small signal stability analysis using linear

techniques provides valuable information about the inherent system dynamic characteristics of the power system and assists in its design and control. While power analyzed accurately from a linearized system model.The small signal stability of the following types of oscillations is of concern:

- Local modes or machine-system modes are associated with the swinging of units at a generating station with respect to the rest of the power system. The term local is used because the oscillations are localized at one station on a small part of the power system. Usually, the local mode oscillations have frequencies in the range of 0.7 to 2.0 Hz.
- Inter-area modes are associated with the swinging of many machines in one part of the system against machines in other parts. They are caused by two or more groups of closely coupled machines being interconnected by weak ties. Large interconnected systems usually have two distinct forms of inter-area oscillations. A very low frequency mode involving all the generators in the system. The frequency of this mode of oscillation is of the order of 0.1 to 0.7 Hz.
- Control modes are associated with generating units and other controls. Poorly turned exciters, speed governors, HVDC converters and static VAR compensators are the usual causes of instability of these modes.
- Torsional modes are associated with the turbine-generator shaft system rotational components. Instability of torsional modes may be caused by interaction with excitation controls, speed controls, HVDC controls and series capacitor compensated lines. The objective of the work is to develop the model of power system stabilizers in MATLAB and design the model of SVC and interconnect with PSS. Increasing attentions has been focused on the effect of excitation control on the damping of the low frequency oscillations, which characterize the phenomenon of small signal stability of synchronous machines. It has been found extremely useful and practical to incorporate transient stabilizing signals derived from speed, bus frequency, electrical power and accelerating power superimposed on the normal voltage error signal to provide for additional damping to these oscillations. Such devices are popularly known as Power System Stabilizers (PSS). The basic function of a PSS is to add damping to the electromechanical oscillations. Essentially, they act through generator excitation system in such a way that a component of electrical torque proportional to speed change is generated.

The Delta-Omega PSS, comprising cascade connected lead-lag networks with rotor speed deviation as input signal, has made significant contribution in enhancing the stability of the power system. A linear dynamic model of the system obtained by liberalizing the non-linear model around a nominal operating point has been used for designing the PSS.

Speed input power system stabilizers when installed on thermal generating units can interact with turbine/generator shaft tensional modes causing them to become unstable. Hydraulic turbine shafts are sufficient stiff for tensional oscillations not to be a problem. The high frequency tensional oscillations are observable in the measured speed signal.

At the torsional frequencies, the gain introduced by the phase lead characteristic of a power system stabilizer amplifies the torsional oscillation. These are further amplified by generator's AVR so that they appear in the generator electrical torque. Shaft torsional modes are very lightly damped and the feedback through the stabilizer and exciter may cause them to become unstable.

EVOLUTION OF POWER SYSTEM STABILIZERS

Virtually, all large size-generating units installed since mid 1960s have been equipped with high initial response excitation systems and PSS. Fast excitation response to terminal voltage variation contributes to the enhancement of transient stability and the power system stabilizers contribute to the damping of system oscillations. The use of power system stabilizers in conjunction with fast response excitation systems with high ceiling voltages has contributed substantially to the improvement of overall system stability.

During the last five decades there have been a lot of developments in power system stabilizers. The following types of PSS have been developed.

- Delta-Omega PSS
- ΔP_e Input PSS
- Accelerating power input PSS
- Dual input PSS
- ANN based PSS

Fuzzy logic PSS

STABILIZER BASED ON FIRST DERIVATIVE OF POWER ANGLE Δ SIGNAL

This stabilizing signal can be derived from phase difference measurement between generator terminal voltage (E_q) and a remote system voltage (E_s). The two voltages Eq and Es were obtained from simulating networks at generator terminals and an angle transducer was used to provide a d.c. signal proportional to the phase angle. The signal was differentiated to provide the required stabilizing signal. This stabilizer suffered from two principal shortcomings. One was due to the variation in the system impedance seen from generator terminals over a wide range, depending on the operating condition; this resulted in instability of the device when the actual system impedance was much lower than the value used in the simulating network. The other shortcoming was caused by unavoidable time lags in the measurement, which had an adverse effect on the stabilizer performance. This method was therefore abandoned in favour of direct measurement of shaft speed.

Power System Stabilizers

PSSs are used to enhance damping of power system oscillations through excitation control. Commonly used inputs are shaft speed, terminal frequency, and power. Where frequency is used as an input, it will normally be terminal frequency, but in some cases a frequency behind a simulated machine reactance (equivalent to shaft speed for many studies) may be employed. The stabilizer models provided in the following sub clauses are generally consistent with the excitation models, with the range of frequency response outlined in the scope. In these cases the stabilizer will need to have the ability to switch between different sets of parameters depending on the mode of operation at a particular time.

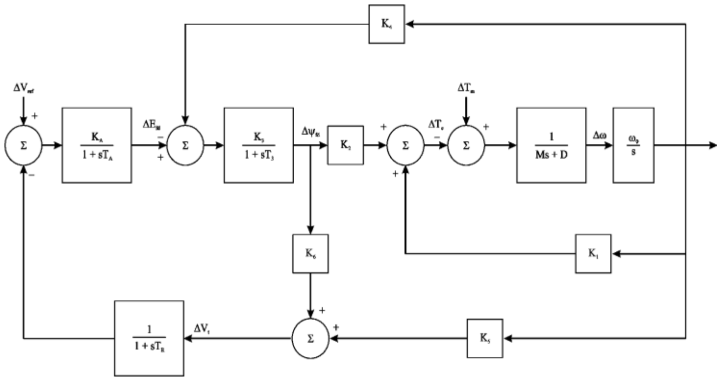

Figure 1: Transfer Function Model of Power System Stabilizers

This stabilizer model, shown in Figure 1, is designed to represent a variety of dual-input stabilizers, which normally use combinations of power and speed or frequency to derive the stabilizing signal. In particular, this model can be used to represent two distinct types of dual-input stabilizer implementations as described as follows:

- Stabilizers that, in the frequency range of system oscillations, act as electrical power input stabilizers. These use the speed or frequency input for the generation of an equivalent mechanical power signal, to make the total signal insensitive to mechanical power change.
- Stabilizers that use a combination of speed (or frequency) and electrical power. These systems usually use the speed directly (i.e., without phase-lead compensation) and add a signal proportional to electrical power to achieve the desired stabilizing signal shaping.

Typical values of M = 5, N = 1 or M = 2, N = 4 are in use by several utilities. Phase compensation is provided by the two lead-lag or lag-lead blocks (T_1 to T_4).

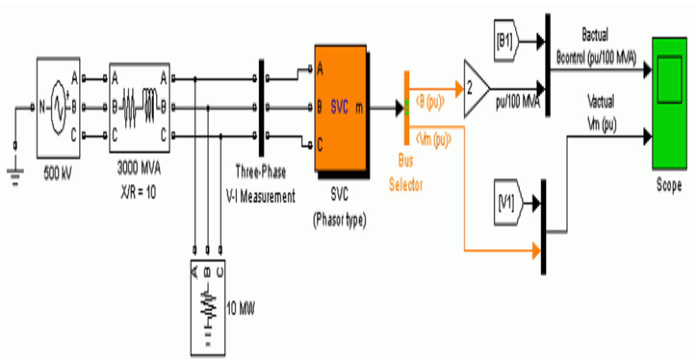

Figure 2: MATLAB Model of SVC Used in Three Phase Line

The SVC is set to Voltage regulation mode with a reference voltage Vref = 1.0 pu. The voltage droop reactance is 0.03 pu/200 MVA, so that the voltage varies from 0.97 pu to 1.015 pu when the SVC current goes from fully capacitive to fully inductive. Double-click the blue block to display the SVC V-I characteristic. The Three-Phase Programmable Voltage Source is used to vary the system voltage and observe the SVC performance. Initially the source is generating its nominal voltage (500 kV). Then, voltage is successively decreased (0.97 pu at t = 0.1 s), increased (1.03 pu at t = 0.4 s) and finally returned to nominal voltage (1 pu at t = 0.7 s).Start the simulation and observe the SVC dynamicresponse to voltage steps on the Scope. Waveforms are reproduced on the figure below. Trace 1shows the actual positive-sequence susceptance B1 and control signal output B of the voltage regulator. Trace 2 shows the actual system positive-sequence voltage V1 and output Vm of the SVC measurement system.

RESULTS AND DISCUSSIONS

A static var compensator (SVC) and power system stabilizers (PSS) are used to improve transient stability and power oscillation damping of the system. The power system illustrated in this example is quite simple. However, the phasor simulation method allows you to simulate more complex power grids.

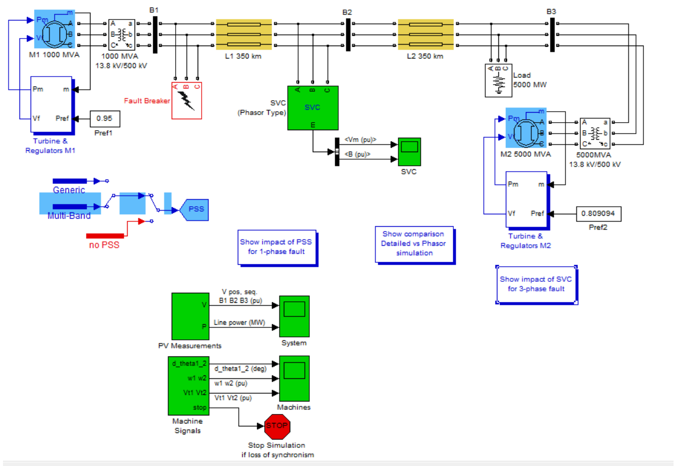

Figure 3: The Phaser Model of SVC Placed at Mid Point of the Transmission Line

The SVC is the phasor model from the FACTS library. Open its dialog box and check in the Power data parameters that the SVC rating is +/- 200 Mvar. In the Control parameters, you can select either Voltage regulation or Var control (Fixed susceptance Bref) mode. Initially the SVC is set in Var control mode with a susceptance Bref=0, which is equivalent to having the SVC out of service. A Fault Breaker block is connected at bus B1. You will use it to program different types of faults on the 500 kV system and observe the impact of the PSS and SVC on system stability. To start the simulation in steady-state, the machines and the regulators have been previously initialized by means of the Load Flow and Machine Initialization utility of the block. Load flow has been performed with machine M1 defined as a PV generation bus (V=13800 V, P=950 MW) and machine M2 defined as a swing bus (V=13800 V, 0 degrees). After the load flow has been solved, the reference mechanical powers and reference voltages for the two machines have been automatically updated in the two constant blocks connected at the HTG and excitation system inputs: Pref1=0.95 pu (950 MW), Vref1=1.0 pu; Pref2=0.8091 pu (4046 MW), Vref2=1.0 pu.

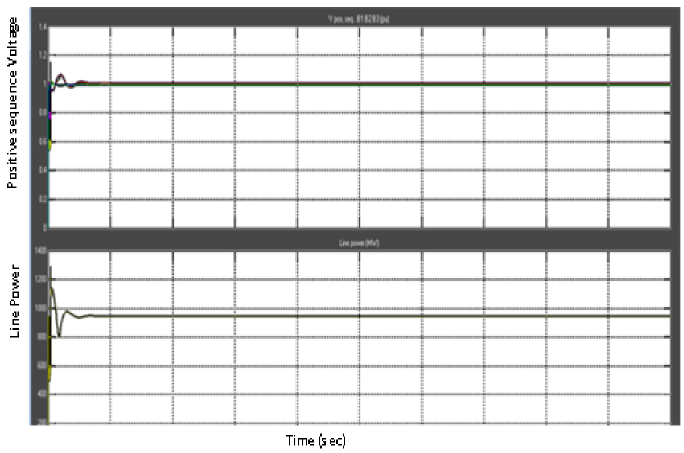

Figure 4: Response of Voltage and Power

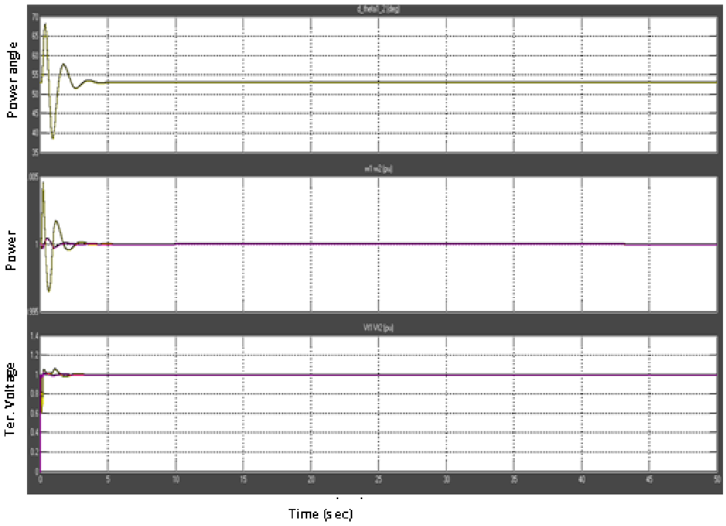

Figure 5: Response of Terminal Voltage, Power and Direct Axis Power Angle

In transmission line by using Power system stabilizers the power, rotor angle and positive sequence voltage stabilizes after having been subjected to disturbances and comes in steady state.

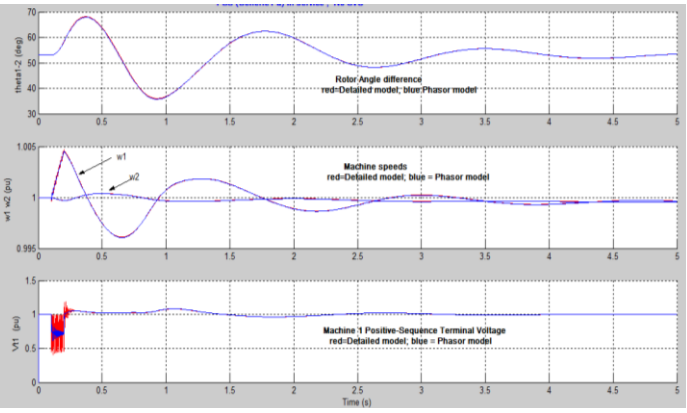

Figure 6: Response of Rotor Angle, Speed of Machine and Positive Sequence Terminal Voltage

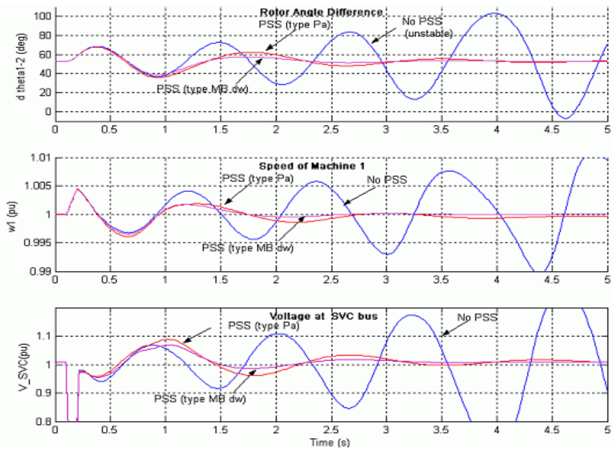

Figure 7: Response of Rotor Angle, Speed of Machine and Voltage at SVC Bus with PSS and without PSS

By simulating over a long period of time (50 seconds) it is noticed that the machine speeds oscillate together at a low frequency (0.025 Hz) after fault clearing. The two PSSs succeed to damp the 0.6 Hz mode but they are not efficient for damping the 0.025 Hz mode. If you select instead the Multi-Band PSS, it is noticed that this stabilizer type succeeds to

damp both the 0.6 Hz mode and the 0.025 Hz mode. You will now repeat the test with the two PSSs out of service. The system is unstable without PSS. We can compare results with and without.

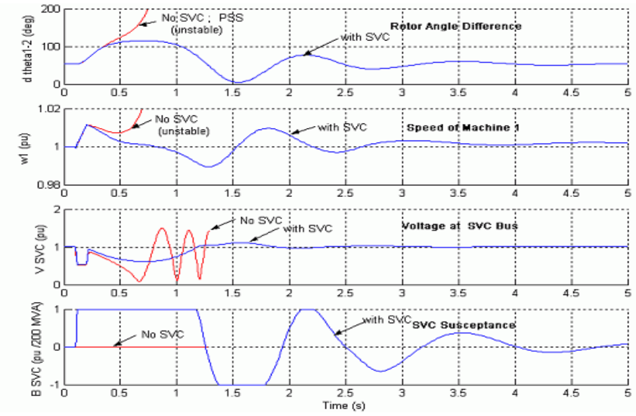

Figure 8: Response of Rotor Angle, Speed of Machine, Voltage at SVC Bus and SVC Susceptance with and without SVC

Without using SVC the responses reveals that the power and rotor angle leads to instability where as by using SVC the Power, Voltage and rotor angle stabilizes within the limit.

CONCLUSIONS

Stabilizers base on direct measurement of turbine-generator shaft speed have been used successfully on several large fossil fuelled and nuclear units it was recognized that these types of stabilizers have some inherent limitations which can restrict the stabilizer gain, and this was found to be too restrictive in many cases and limited the overall effectiveness of the stabilizer. In addition, the stabilizer had to be custom designed for each type of generating unit depending on its torsional characteristics.

The Developed model of power system stabilizers using MATLAB is simulated. The dynamic responses for rotor angle, speed of the machine, Voltage and SVC suseptance for single phase and three phase are obtained separately. The graph for stability of power system stabilizers with SVC and without SVC are simulated. The comparative study reveals that the stability of the power system stabilizer with SVC is within the limit and without SVC the machine is out of stability limit.

REFERENCES

1. Abdalla, Hassan and Twegi, "Coordinate stabilization of a multi-machine power system", IEEE transaction on power apparatus and system, Vol. PAS- 102, Feb 1983, pp.290-299.

2. Antonio do Bomifim L.B., Glauco N. Taranto, and Falcao Djalma M., "Simultaneous tuning of power system damping controllers using Genetic Algorithms", IEEE transactions on power system, Vol. 15, No:l, Feb-2000, pp. 163-169

3. Abdel-magid Y.L, and Abido M. A., "Optimal Multiobjective Design of Robust Power System Stabilizers using Genetic Algorithms", IEEE Trans, Power Syst.,Vol. 18,no.3,August -2003,pp. 1125

4. Bhattacharya K.,. Nanda J, and Kothari M.L., "Optimization and performance analysis of conventional power system stabilizers", Electrical power and Energy System, vol. 19, no: 7, 1997, pp. 449-458.

5. El-Metawally K.A.and Malik O.P., "Fuzzy logic Power system stabilizers", IEE proceedings of Generation, Transmission and Distribution, Vol 142, No: 3, May 1995,pp. 277-281.
6. Gibbard M.J., "Coodinated design of multi-machine power system stabilizers based on damping torque concepts", IEE Proceedings, Vol. 135, Pt, C, no. 4, July 1988, pp. 276-284.
7. Hassan M..A.M, Malik O.P. Hope G.S, "Fuzzy logic based stabilizer for a synchronous machine", IEEE transactions on energy conversion, Vol 6, no:3, Sept 1991,pp. 407-413.
8. Hiyama T., "Robustness of fuzzy logic power system stabilizers applied to multi-machine power system", IEEE Transactions on Energy Conversion, Vol.9, Issue: 3, Sept. 1994m p-451.
9. Handschin E., Hoffmann, T. Reyer T., Stephanblome Th., Schlucking U., Westermann D. and Ahmed S.S.,"A new method of Excitation control based on Fuzzy Theory", IEEE Transcations on power systems, Vol.9, no.l, Febraury- 1994,pp.533-539.
10. Hsu Y. Y.and Cheng C.H., "Design of Fuzzy power system stabilizers for multi- machine power system,"IEE procedings, Vol. 137, pt. C, no: 3 May 1990,
11. Hsu Yuan-Yih, and Chern-Lin Chen,"Identification of optimum location for stabilizers applications using participation factors", IEE Proc, vol. 134, Pt. C, no. 3, May 1987.
12. Kothari M.L.& Jeevan Kumar T., "Anew approach for designing Fuzzy logic Power system stabilizers", International Conference on Artificial Intelligence in Engineering & Technology, IC AIET-2004, Organized by IEE.
13. Kothari M.L., Sharma A., and Chaudhary A.K., "Fuzzy logic Power system stabilizers", Journal of Institute of Engineers (Electrical Division), India, 82(1): 24-31. June-2001.
14. Hoang P.and Tomsovic K., "Design and analysis of an adaptive Fuzzy Power system stabilizers", IEEE Transactions on Energy conversion, Vol 11, no:2, June 1996, Organized by IEE.

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